Cosmic Times: 1955

Cosmic Times is a series of six posters with classroom lessons that trace the development of our understanding of the nature of the universe during the past century.

This poster is the third edition of the *Cosmic Times*, dated to coincide with Einstein's passing. Much has happened since 1929, with developments in previous stories and completely new discoveries. Astronomers discovered there were two populations of Cepheid variables, leading to a re-calibration in the use of the Cepheids as standard candles and a doubling of the size of the Universe. A debate raged between whether the Big Bang or the Steady State theory correctly described the origin and nature of the Universe. Also, astronomers not only recognized the distinction between novae and supernovae, but that there different types of supernovae. Finally, astronomers get their first "glimpse" of objects emitting in a region of the electromagnetic spectrum other than optical light.

The language in the 1955 newspaper mimics the style of writing that would have appeared in a newspaper at that time. While this is getting closer to familiar language and sentence structure of modern newspapers, it may still be a bit difficult for students to read.. The poster also shows a layout that mimics the papers of the time. However, we have taken some creative license to make it more readable in a classroom setting.

The *Cosmic Times* website, http://cosmictimes.gsfc.nasa.gov/, provides a complete teacher guide for this poster and the accompanying lessons. There you can also find two newsletter versions of the poster: one of the newsletters contains the same text as the poster, while the other translates the text to a slightly lower reading level. The web site also includes a glossary. We provide here a summary of the articles, a synopsis of the lessons, and one of the lessons.

Summary of the Articles

(for more information, see
http://cosmictimes.gsfc.nasa.gov/1955/guide/teachers_guide.html)

'Yardsticks' in Neighbor Galaxy Double Universe's Size

This article describes how astronomers discovered a miscalibration in the Cepheid distance scale. This arose from the discovery of the existence of two populations of Cepheids with two different period-luminosity relationships. When this miscalibration was corrected, the size of the Universe doubled overnight.

Origin of Everything

As of 1955, there were two equally likely theories for the origin of the Universe – the steady-state theory and the evolutionary Universe theory (later known as Big Bang theory). Although predictions were made by both theories, at the time, the observational evidence was insufficient to decide between them.

Hoyle Scoffs at "Big Bang" Universe Theory

Ironically, the biggest detractor of the evolutionary Universe theory ended up coining the phrase by which it is became to be known – the Big Bang. Hence, everyone seems to contribute to the progress of science!

Death of a Genius: Albert Einstein 1879 - 1955

This article shows how Einstein's death was felt the whole world over.

It's a Star! It's a Nova! It's Super-nova

This article begins the important story of supernovae by picking up with the discovery made that these stellar explosions can be classified into two types: novae and super-novae. Further, these super-novae can be split up into two different kinds – Type I which show no signs of hydrogen in their spectrum and Type II which do show hydrogen.

Radio 'Ear' on the Universe Being Built

By the mid-1950s technologies inherited from World War II allowed astronomers to look at radio waves emitted by objects in the Solar System and beyond. Hence astronomy was no longer confined to the realm of optical observations.

Summary of 1955 Cosmic Times Lessons

Each of the lessons uses elements of the 5E model of Engage, Explore, Explain, Elaborate, and Evaluate. These lessons may be downloaded from
http://cosmictimes.gsfc.nasa.gov/1955/1955.html

The Evidence is Clear! (grades 9-12)
Students sort cards bearing evidences for the Steady State and the Big Bang according to whether they are observations or inferences. Students see that good science is empirically based, while inferences can play an important role if based on sound theoretical explanations. This lesson is given below.

Cosmic Jeopardy (grades 7-12)
Students play Jeopardy! based on the articles in the 1955 *Cosmic Times*. The teacher may use the answers and questions provided, or have the class research topics covered in the 1955 edition to create their own.

Big Bang Science Fiction (grades 7-12)
Playing one of five roles – science student, NASA scientist, travel agent or TV announcer – students create a fictional narrative about the beginning of time at the Big Bang. The lesson uses the RAFT (Role, Audience, Format Topic) format.

Discovering 'Yardsticks' are 'Metersticks' (grades 9-12)
Students observe two light sources that are said to be equally bright but clearly are not. By discussing this discrepant event, students mirror the problem created by Shapley when he used the Cepheids to determine distances without knowing that there were two different types of Cepheids.

Hubble's Law Mis-calibration Extension (grades 9-12)
This lesson is an extension of the *Cosmic Times* 1929 lesson in which students reproduce a plot of Hubble's Law. In the extension, students modify the size of the galaxies, and hence their distance determinations, to come up with an alternate Hubble's Law.

The Evidence is Clear!

Grade Level: 9 through 12
Class time: one hour plus summary

Summary

Students consider observations and inferences about the Steady State and Big Bang theories.

Objectives

- Distinguish between data collected from empirical observations and inference which may or may not arise from data.
- Compare and contrast the Steady State and Big Bang theories for the origin of our universe.

National Science Education Content Standards

NS.9-12.1 SCIENCE AS INQUIRY
NS 9-12.4 EARTH AND SPACE SCIENCE
- Origin and Evolution of the Universe

Knowledge Prerequisite

Students should have read the *Cosmic Times* 1955 article "Origin of Everything: Hot Bang or Ageless Universe" and be familiar with the general ideas presented in both the Steady State and Big Bang Theories. Spectral Red Shift due to expansion and cosmic microwave background (CMB) are important terms in the study of cosmology. Use the internet to find out more about them.
Important terms:

- Light year- the distance light travels in one year. The light we are viewing now from a distance of 500 light years took 500 years to get here. We are "seeing" the past!
- Interstellar reddening- Light traveling through space from very distant objects is scattered by clouds of dust in space. More blue light is scattered than red so objects will appear more reddish than they actually are. Many of the blue spectral lines disappear
- Red shift- Objects moving away from the viewer appear to be more reddish because all of the wavelengths of light coming from them are stretched. All of the spectral lines are shifted toward the red end, but none disappear. See http://www.classzone.com/books/earth_science/terc/content/visualizations/es2802/es2802page01.cfm

Teacher Background

Consult the sites listed here as well as k-12 student and college astronomy texts about cosmology.
http://map.gsfc.nasa.gov/m_uni/uni_101bb1.html,
http://cosmology.berkeley.edu/Education/IUP/Big_Bang_Primer.html,
http://www.damtp.cam.ac.uk/user/gr/public/bb_home.html,
http://www.newtonphysics.on.ca/BIGBANG/Bigbang.html,
http://curious.astro.cornell.edu/cosmology.php
http://www.answers.com/topic/steady-state-theory

Materials

One set of 32 Evidence cards per pair of students (see below)
Note - a shorter version of the activity may be done using 16 cards. See p. 4.
Two large (about 40x80 cm) sheets of butcher paper for each pair of students

Procedure for Students

I. Engagement

You arrive at school one morning and observe a group of your friends clustered in the hall. They are laughing and seem to be passing something around among the group. Each person looks at it for a few seconds, then bursts out with new peals of mirth and releases it to someone else who eagerly grabs it away. Is it a picture; are they reading something; is it some object or toy? Then you remember that note of passionate love you were writing to your sweetheart and somehow lost yesterday. When they see you, the group falls silent, still grinning, and quickly disperse in different directions at the sound of the morning bell.

What has happened? Did the group read your note? Perhaps their actions had nothing to do with you at all. What did you actually observe? What might you infer from those observations? How do you find out what was really happening? Believe it or not, this is exactly what science is all about!

II. Exploration

Science is the process of trying to find out what is happening. Scientists make careful quantitative observations of the world around them. Then they try to explain the meaning of those observations by making inferences which lead to the design of experiments which lead to new observations and new inferences. In the best scientific procedure, inferences are based on direct observation. As continued observations lead to similar inferences, scientists begin to construct a "model" which is an idea which we think represents how the real world works. As we collect more bits of information through observations, we decide whether they support or refute the model we have built. Sometimes our minds "jump to conclusions" and make inferences or even models before we have collected enough observations.

In this activity you will be examining statements about two theories which try to explain our understanding of the nature of our universe and how it began.

Working with a partner, take turns drawing an Evidence card and decide if the statement describes direct evidence as an observation/ experiment or if it describes an inference or interpretation. Make two piles, one for observations, and one for inferences. If you and your partner disagree, set the card aside until later. You will find two cards labeled Model

Reread the "Origin of Everything" article in the 1955 *Cosmic Times*.
Label one of the large sheets Steady State Theory and the other Big Bang Theory. Place each Model card under the theory it describes. Make two columns down each sheet with one labeled OBSERVATION/experiment and the other labeled INFERENCE/ interpretation.

Beginning with your stack of observation Evidence cards, decide with your partner which theory the observation supports. Place the card on the appropriate Theory sheet. Then do the same with your stack of inference Evidence cards. When your teacher tells you, you will exchange places with another team and examine their placement of cards. If you disagree, discuss the matter among the four of you and try to come to a consensus. Try to resolve any cards you set aside. Some blank cards are available so you can make a copy of any piece of evidence you may feel belongs in more than one place.

III. Explanation

Remember that the most reliable scientific explanations are based on observation and experiment. Inferences and interpretations must ultimately be based on actual data. As you examine your Theory sheets, which one contains more examples of observations and experimental data? Which theory is supported mostly by conjecture and "guessing"? Do you have enough information to prove either of these Theories?

IV. Evaluation

Your teacher may display the class results on the board and discuss any which caused disagreement. Return to your own seat and write a summary of the theory you feel has the most reliable evidence supporting it.

Incidentally:
Later in the day one of your friends shows you a photograph of his little brother trying to paint their cat with whipped cream. The expression on the cat's face indicates disapproval while the child's shows deep concentration. You laugh….could this be what the group was looking at earlier? Are you sure?

Teacher notes

Some of the information on the Evidence cards may be very strange to the students and they may not totally understand the statements. However you can guide them to make a list of words which are more likely to represent inference and those words which indicate actual observations. For instance could, might, suggest, should, predicts, ought to be, theoretical are all terms which would be appropriate for inferences. Specific dates, records of data from specific experiments and numerical records indicate observations. The term empirical refers to actual data from an observation. The most important lesson to be learned from this activity is that good science is experimentally based. Inferences are valuable evidence only if they are theoretical explanations of actual data. The Steady State theory lost most of its support with the prediction and discovery of the cosmic microwave background radiation in 1965. Those who supported it based most of their belief on inferences which had little data to support them. Although the hot Big Bang model has been successful in describing most of the observations we have recorded so far, there are unanswered questions. Refer to http://www.damtp.cam.ac.uk/user/gr/public/bb_problems.html.The final explanation of the origin of the universe is yet to come.

Results may vary:
(For a shorter version, use cards 3,9,5,6,7,10,11,12,8,24,26,16,27,17,20,25)
- Steady State observations: 2, 3, 9
- Steady State Inferences: 1,4,5,6,7,10,11,12,13,14,15

The observations do not lead to any of the inferences, but the information that Hoyle wrote more science fiction that science may suggest a pattern of thinking which was comfortable with "poetic license".

- Big Bang observations 2, 18, 19 lead to inference 21 that the universe does show difference through time.
- Big Bang observations 8, 23, 24 lead to inference 26 that some of the low mass elements could only be produced during such a violent event.
- Big Bang observations 22 and 30 lead to inference 29 that the Big Bang would create a perfect Black Body radiation.
- Big Bang observation 16 and 27 lead to inference 17 that the Cosmic Microwave Background indicates a Black Body.
- Both inferences 29 and 17 lead to inference 32
- Big Bang observation 20 leads to inference 25 that the universe is expanding.
- Big Bang inference 28 is suggested by inferences 17 and 29

The Evidence Cards:

1. MODEL: We think that the universe is ever expanding, without beginning or end. The universe is the same at all points, in all directions and at all times. Galaxies of all ages are intermingled.

2. In 2002 the Hubble Deep Field photograph showed the most distant, therefore oldest, view of the universe. It shows unusual galaxies shaped like tooth picks and links on a braclet which are not similar to galaxies which have formed more recently.

3. In 1946 Hoyle, Bondi, and Gold saw a movie, The Dead of Night, in which the ending of the movie had circled back to the beginning. Hoyle noted that unchanging situations need not be static.

4. Hermann Bondi thought that if the universe was expanding, new matter would need to be created continually in order to keep density constant.

5. Bondi suggested that new matter could be created spontaneously due to the interchangeability of matter and energy.

6. In order to both expand in size and create new matter, a reservoir of energy is needed. To prevent the energy from being used up, Hoyle proposed that the energy is negative so that expansion and creation work against each other and equilibrium is maintained.

7. Hoyle wrote that matter could arise from a field generated by matter that already existed, "chasing its own tail", in the same manner as the ghost film.

8. Experimental chemistry has shown that all of the naturally occurring elements except Hydrogen can be produced inside of stars. Spectroscopy of starlight has confirmed the presence of most of them.

9. Fred Hoyle wrote, and had published, 15 science fiction novels and 14 non- fiction works.

10. Hoyle proposed a C-field area in space which could have a negative pressure in order to be consistent with conservation of energy and drive the expansion of the universe.

11. It would be necessary to spontaneously produce Hydrogen at a rate of 1 atom/cubic meter/billion years. Also it would be necessary to produce small amounts of Deuterium, Helium, and Lithium, but the amounts would be so small that they would not be directly detectable.

12. Cosmic background radiation was possibly caused by light from very distant, therefore ancient, galaxies which has been scattered by galactic dust.

13. Theoretical studies suggest that collisions between light energy photons and atoms of matter result in loss of energy of the photons. As they approach us they would appear to be red shifted.

14. If the red shift of distant galaxies is caused because the light coming from them is losing energy as it collides with intergalactic matter, the universe might not really be expanding. It could just be very, very large and there is a lot of matter out there scattering light.

15. If the universe had been the size of an electron when it was only a fraction of a second old, it must have been a black hole. Therefore its gravity would have been so intense that it could not have expanded to what we see today.

16. The cosmic microwave background was discovered in 1965 by Wilson and Penzias. It is very uniform and comes from every direction.

17. A hot big bang would have produced very high energy, short wavelength radiation. The red shift caused by the expansion of the universe over billions of years would produce a smooth, uniform long wavelength (microwaves) which would come from every direction.

18. Maarten Schmidt produced a survey of quasars, small but very brilliant extragalactic systems discovered in 1966. They are found only at several billion light years, but none are found nearby.

19. Radio galaxies have been observed most frequently at billions of light years from earth, but much less frequently at closer distances.

20. In 1929 Hubble observed that every galaxy he saw exhibited a spectral red shift which was proportional to its distance from us.

21. Very distant objects such as quasars and radio galaxies which appear very far away, but not nearby, could mean that the universe was different long ago than it is today and therefore is not constant in time.

22. The cosmic microwave background (CMB) produces a spectrum which fits the curve for an ideal Black Body radiation which was originally 3000K degrees but is today only 2.73K

23. Although the synthesis of most elements can be explained by the fusions within stars, no theoretical method can account for the Deuterium or Helium 3 (atomic masses of 2 and 3) which has been observed.

24. The observed amount of Helium4 today is more than can be accounted for by the fusion of Hydrogen in stars. Almost one quarter of the known matter in the universe today is Helium4.

25. Hubble concluded that all of the galaxies he observed were moving away from us at a speed proportional to their distance from us.

26. Atoms with masses of one to four amu could have been produced in the extremely high energy in the very early period shortly after the Big Bang. That could account for the Hydrogen, Deuterium, Helium3, and some Lithium found in the universe today.

27. The cosmic microwave background is uniform in temperature to better than one part in one thousand.

28. The uniformity of the CMB would be difficult to explain if there were many different sources and ages of radiation.

29. In the early universe there were no atoms, only free electrons and nuclei. The photons of energy could scatter off electrons and the tiny universe would have been a dense collection of photon energy called a Black Body.

30. The FIRAS experiment between 1989-90 on NASA's COBE satellite shows the CMB closely follows the Black Body spectrum at 34 equally spaced points on the curve.

31. MODEL: We think that the universe did begin from nothing as a singularity about 15 billion years ago and has been expanding ever since.

32. The Big Bang Theory predicts a perfect Black Body temperature curve and a background radiation with very slight differences in density throughout.